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ORIGINAL RESEARCH

COMPARISON OF LUMBOPELVIC RHYTHM AMONG ADOLESCENT SOCCER PLAYERS WITH AND WITHOUT LOW BACK PAIN

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ABSTRACT

Background: Hip–spine incoordination can cause low back pain (LBP) in adolescents. Hip–spine coordination, including the lumbopelvic rhythm (LPR) and the lumbar–hip ratio (LHR), can be used to assess lower limb and spine function. However, there are no reports of the values of LPR or LHR in adolescent soccer players with and without LBP.

Purpose: The purpose of this study was to clarify the effect of LBP on LPR and LHR during trunk extension among adolescent soccer players.

Study Design: A cross-sectional observational study.

Methods: One hundred and nine adolescent soccer players were recruited and divided into two groups, one with and one without LBP. Using three-dimensional motion analysis, participants range of motion (ROM) of the lumbar spine (LS) and hip during trunk and hip extension was measured to calculate the LPR and LHR. Paired, two-tailed *t*-tests were used to compare the LS and hip ROM between the non-LBP and LBP groups, two-way repeated measures analysis of variance was used to compare time with the non-LBP and LBP groups for LHR, and linear prediction was used to describe the LPR.

Results: The maximum LS ROM in the LBP group was significantly less than that in the non-LBP group by 6.6° (p = .005). There was no difference in the maximum hip ROM between the groups (p = .376). The LHR did not change during trunk extension (F [4, 428] = 1.840, p = .120), the mean LHR was 4.6 in the non-LBP group and 3.7 in the LBP group, and there was no difference between the groups (p = .320). The linear function of the LPR indicated, that when the hip joint was extended by 1°, the LS extended by 3.2° in the non-LBP group (R^2 = .997, p < .001) and 2.8° in the LBP group (R^2 = .999, p < .001).

Conclusion: LBP inhibited lumbar motion relative to hip extension as LPR was smaller in the LBP group than in the non-LBP group. However, there was no difference between the groups in LHR because inter-individual variability affected the LHR.

Level of Evidence: 3b

Keywords: Adolescent; low back pain; lumbar–hip ratio; lumbopelvic rhythm; trunk extension

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Conflict of interest: The authors declare that they have no conflict of interest in the authorship and publication of this contribution

Acknowledgments: The authors thank Mr. Nao Shinoda at FC GONA and the TORII laboratory staff's assistance with data collection. We presented part of this study in a Poster session at the Gait and Clinical Movement Analysis Society (GCMAS) 2016 Meeting, which was held in Memphis, Tennessee, USA from May 17–20, 2016

Funding: This study was supported in part by a research grant from JSPS KAKENHI (Grant No. 15K16492)

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INTRODUCTION

There have been some reports on adolescent lumbar disorders.[1-6] Low back pain (LBP) is the seventh most common disorder and sports injury,[1] and the fourth most common soccer-related disorder.[6] The odds ratio for soccer-related LBP ranges between 1.6 and 1.7.[2,3] Factors related to LBP during adolescence include disk degeneration[4] and spondylolysis,[5] with the pathomechanics of disk degeneration relating more to trunk flexion than trunk extension.[7,8] However, trunk extension also relates to intervertebral disk disorders. Jinkins et al.[8] measured disk degeneration using MRI during trunk extension in the upright position and reported the relationship between lumbar extension and posterior disk herniation. In adolescent athletes, excessive lumbar extension with rotation can cause mechanical stress to the contralateral pedicle and result in lumbar spondylolysis.[9] The causative factors for LBP in this age group include lower limb muscle tightness,[10] trunk instability,[11] excessive lumbar motion,[9] and hip–spine incoordination.[12] Therefore, the assessment of adolescent LBP during trunk extension is important.

Hip and spine coordination, which is known as the lumbopelvic rhythm (LPR), refers to the concurrent movement of the hip joint and lumbar spine (LS) as they contribute to locomotor function of the lower limbs.[13-15] LPR can also be expressed as the lumbar–hip ratio (LHR), which represents the ratio of LS to hip range of motion (ROM), where an LHR ≥1.0 indicates that lumbar motion is greater than hip motion. On the basis of reports on LPR,[16] LPR can be evaluated by using a graph with the hip joint angle plotted along the x-axis and the LS angle is plotted along the y-axis. If the LHR does not change, the LPR is appropriate for a linear function. However, no study has reported the LPR or LHR values among adolescent soccer players with and without LBP.

Authors who have studied the LS ROM during trunk extension in the standing position have reported inconsistent findings because of variation in the participants' ages and in the methods used.[10,15,16] Wong and Lee[15] used a 3SPACE Fastrak® in participants (mean age 42 years) and reported an LS ROM of 15.5°, whereas Tojima et al.[16] used a VICON motion capture system in participants (mean age 33 years) and reported an LS ROM of 30.1°. Kujala et al.[10] reported an LS ROM of 30° measured using a flexicurve technique in soccer players (mean age 12 years). Furthermore, Wong and Lee[15] and Tojima et al.[16] reported maximum hip ROMs during trunk extension of 15.7° and 17.1°, respectively.

The medical implication of clarifying the LPR and LHR is that it would help with the assessment of lumbar movement in patients with spinal or hip disorders, such as hip–spine syndrome.[12] Assessment of lower limb and spinal malfunction can be made according to deviation from the normal ranges of LPR and LHR values only if those normal ranges are known. The purpose of this study was to clarify the effect of LBP on LPR and LHR during trunk extension among adolescent soccer players. The hypothesis was that LBP would affect LS ROM and decrease the LPR and LHR.

METHODS

Participants

This study was approved by the office of research ethics (# 2013-167[1]) at Waseda University. After the team coach gave permission for measurements to be taken, we asked all players to participate in our study. Informed consent was obtained from 119 male soccer players of the town recreation league team. The inclusion criteria were as follows: no prior spine or lower limb surgery, no obvious spinal and lower limb deformities, and no painful lower limb joints. Ten participants were excluded from participating, five participants trunk extension could not be measured and five participants could not perform trunk extension because of pain.

In total, 109 male soccer players (age, 13.1 ± 0.9 years; height, 160.0 ± 9.3 cm; weight, 48.5 ± 8.5 kg; body mass index [BMI], 18.8 ± 1.9 kg/m^2) were analyzed. For LBP assessment, a doctor asked participants to perform trunk extension as much as they could and to maintain the maximum position for three seconds in the standing position. The doctor asked each participant if LBP appeared during trunk extension and at end ROM. Based on the findings, the participants were divided into two groups: an LBP group (n = 44; age, 13.1 ± 0.9 years; height, 158.8 ± 9.3 cm; weight, 47.7 ± 8.3 kg; BMI, 18.8 ± 1.8 kg/m^2) and a non-LBP group (n = 65; no-LBP;

age, 13.1 ± 0.9 years; height, 161.7 ± 9.0 cm; weight, 49.2 ± 8.1 kg; BMI, 18.7 ± 2.0 kg/m^2) with and without LBP, respectively.

Devices and procedures

Three-dimensional (3D) motion analysis was performed (Qualysis Track Manager; Qualysis AB., Sweden) at a sampling frequency of 60 Hz, using six cameras were used. All cameras were placed 3.3 m behind the participants; two cameras each were located at the levels of their pelvis, knees, and ankles. A single physical therapist then placed 13 spherical markers, each measuring 14 mm in diameter, on the following anatomical landmarks (Figure 1): thoracolumbar landmarks (spinous processes of the tenth and twelfth thoracic spines, and the right and left paravertebral muscles at T11), pelvic landmarks (right and left posterior superior iliac spines, and S3), and femoral landmarks (greater trochanter, medial epicondyle, and lateral epicondyle).[16,17] Measuring lumbar motion with this method has sufficient repeatability (intraclass correlation coefficient ≥.8) and reliability (canonical measure of correlation ≥.99) during trunk extension.[17]

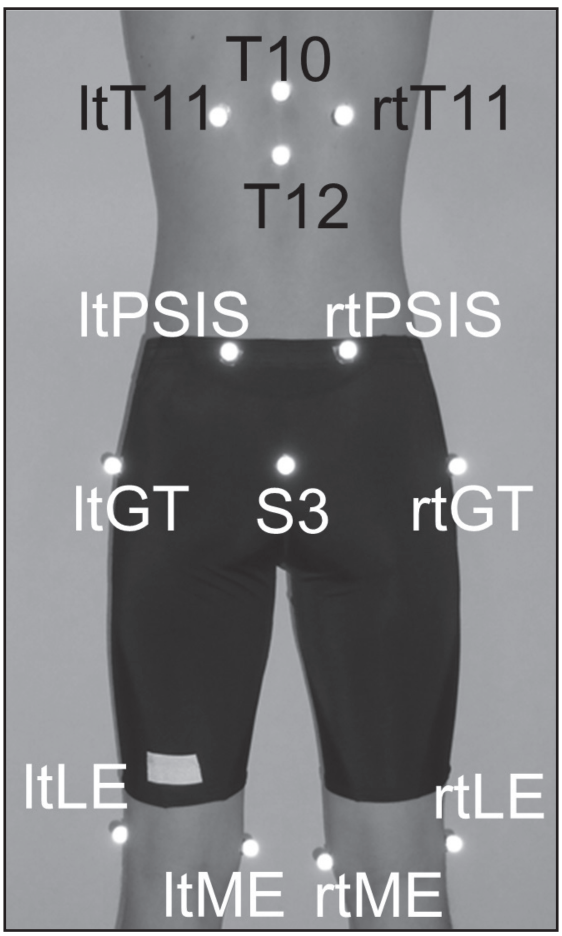

Figure 1. *Location of reflective markers on the pelvic, thoracolumbar, and thigh regions*
Abbreviations for below the figure: lt = left; rt = right; T10 = tenth thoracic vertebra; T11 = eleventh thoracic vertebra; T12 = twelfth thoracic vertebra; S3 = third sacral vertebra; PSIS = posterior superior iliac spine; GT = greater trochanter; ME = medial epicondyle; LE = lateral epicondyle.

The participants were asked to stand with their feet shoulder-width apart and perform trunk extension (without the arms touching anywhere) three times at their own speed. Before measuring their trunk extension, participants practiced trunk extension three to five times. In each participant, the data of three trials were averaged to give a mean test value.

Analytical procedures

Visual3D v5 (C-Motion, Inc., MD, USA) was used for analysis. A low-pass filter at 6 Hz was used to eliminate noise from the raw data. Then, the LS angle from the thoracolumbar segment with respect to the pelvic segment (i.e., the sum of L1–L5 vertebral movements)[17] and the hip joint angle from the femoral segment with respect to the pelvic segment was calculated.[16] The hip joint angle was used to define trunk extension. The start of extension was defined as the point when the hip joint angle was ≥1°, and the end of extension was defined as the point of the maximum hip angle.[16] The LHR was calculated as the ratio of LS ROM to the average of the right and left hip ROM. During trunk extension, decreasing LHR and LPR values indicate decreasing lumbar extension relative to hip extension. After normalizing the phase to 100% using MATLAB (MathWorks, Natick, MA), LHRs were statistically analyzed from 0% to 100% at intervals of 25%.

Statistical analyses

IBM SPSS Statistics, Version 19.0 (IBM Corp., Armonk, NY, USA) was used for the statistical analyses. Paired, two-tailed *t*-tests were used to compare the LS and hip ROM, as well as the mean LHR, between the non-LBP and LBP groups. Two-way, repeated-measures, analysis of variance was used to analyze time with the LBP and non-LBP groups for LHR. Linear prediction was used to describe LPR,[16] using a graph with the hip joint angle plotted along the *x*-axis and the LS angle plotted along the y-axis. The level of statistical significance was set at $p < .05$.

RESULTS

LS and hip ROM

There was no difference in the mean maximum hip ROM between the groups with and without LBP (p = .376, 95% confidence interval for difference [CI] = −1.049 to 2.755). Concerning the mean maximum LS ROM, the LBP group had significantly less extension ROM than the non-LBP group, by 6.6° (p = .005, 95%CI = 2.086–11.163, Table 1).

Comparison of the LHR between the study groups

There were no differences in LHR between the non-LBP group and the LBP group during trunk extension (F [4, 428] = 1.840, p = .120). The mean LHRs were 4.6 ± 5.1 and 3.7 ± 3.4 in the non-LBP and LBP groups, respectively (Figure 2 and Table 1). There was no difference in the mean LHR between the groups [p = .320, 95% CI = −0.874 to 2.650].

Comparison of the LPR between the study groups

The lumbopelvic rhythm for trunk extension was expressed by a linear function (non-LBP group, $y = 3.2x - 0.4$, $R^2 = .997$, $p < .001$; LBP group, $y = 2.8x - 0.2$, $R^2 = .999$, $p < .001$; Figure 3). According to the linear function, when the hip joint was extended by 1°, the LS extended by 3.2° in the non-LBP group and 2.8° in the LBP group (Table 1).

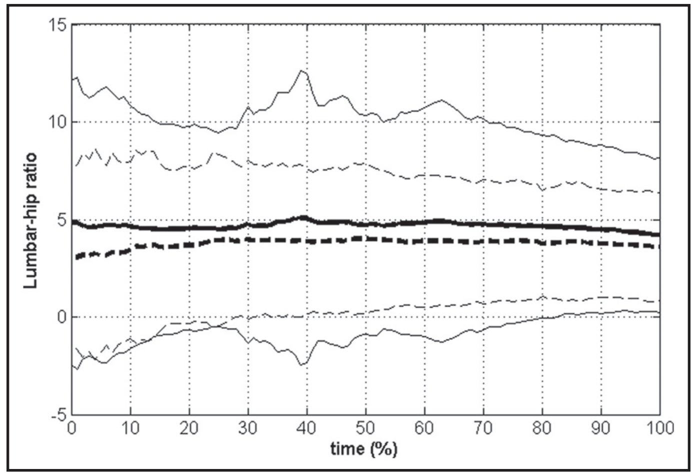

Figure 2. *The mean (thick lines) and standard deviation (thin lines) of the lumbar–hip ratio during trunk extension. The broken lines represent the group with low back pain and the unbroken lines represent the group without low back pain.*

DISCUSSION

In this study, 3D motion analysis was used to clarify the impact of LBP on LPR and LHR during trunk extension among adolescent soccer players. LBP during trunk extension was shown to be associated with decreased lumbar extension relative to hip extension.

Table 1. *The mean parameters of the non-LBP and LBP groups, and other reports.*

	non-LBP group		LBP group			Kujala et al.[10] flexicurve technique, 19 soccer players	Tojima et al.[16] VICON system, 8 non-LBP participants	Wong and Lee [15] 3SPACE Fastrak, 20 non-LBP participants	Wong and Lee [15] 3SPACE Fastrak, 24 LBP participants
	Mean	SD	Mean	SD	p				
Age (years)	13.1	0.9	13.1	0.9	.746	12	33	42	41
LS ROM (°)	34.8	12.3	28.2	10.8	.005	30.0	30.1	15.5	14.9
Hip ROM (°)	11.0	5.0	10.1	4.8	.376	—	17.1	15.7	13.5
Lumbar–hip ratio	4.6	5.1	3.7	3.4	.320	—	1.2-1.9	1.4	1.4
Lumbopelvic rhythm (°)	3.2	—	2.8	—	—	—	1.9	—	—

Abbreviations: LBP= low back pain; LS= lumbar spine; non-LBP= no low back pain; ROM= range of motion.

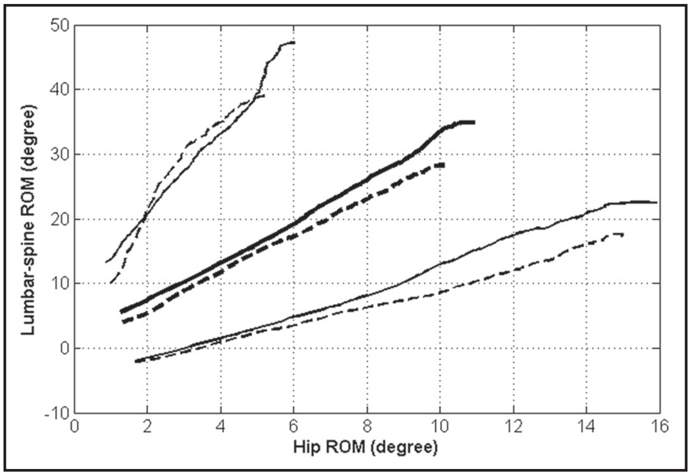

Figure 3. *The mean (thick lines) and standard deviation (thin lines) for lumbopelvic rhythm during trunk extension. The broken lines represent the group with low back pain and the unbroken lines represent the group without low back pain. Abbreviations for below the figure: ROM = range of motion.*

LS and hip ROM

Previous studies have reported on the LS and hip ROM during trunk extension in adults. The current results for LS ROM in adolescents with LBP are comparable to those in the reports by Kujala et al.[18] and Tolima et al.;[16] however, the LS ROMs in adolescents without LBP were larger than those reported previously for adults. Overall, it was concluded that LBP inhibited lumbar extension, with LS ROM being smaller in the LBP group than in the non-LBP group during trunk extension. The results for adolescent hip ROM were less in both groups than those reported by Wong and Lee[15] and Tolima et al.[16] for adults.

It was also considered that potential confounders may have affected the current results. There were large standard deviations for both LS and hip ROMs, with both varying during trunk extension because of inter-individual variability seen in ROM that may have been based on speed. After a few months or a year, participants may or may not have had LBP. However, participants were not observed longitudinally in the current study, so these potential confounders must be considered to have affected the LS and hip ROMs.

The LHR

LBP inhibited LS motion relative to hip extension. Therefore, the LHR was less in the LBP group than in the non-LBP group. However, there was no significant difference in LHR between the groups. The different patterns of trunk extension did not alter the LHR between the two groups. Previously reported LHR values are 1.2–1.9 during trunk extension[16] and 1.4 at maximum trunk extension.[15] The result for the LHR in adolescents was larger than that reported in previous studies among adults,[15,16] because the participants extended their hips less than subjects in previous studies. Furthermore, lumbar extension was greater in the non-LBP group than that in previous studies among adults.[15,16]

The LPR

LPR was appropriate for linear function because the LHR did not change during trunk extension. The linear function indicated, that when the hip joint was extended by 1°, the LS extended by 3.2° in the non-LBP group and 2.8° in the LBP group. Tojima et al.[16] reported, that when the hip joint was extended by 1°, the LS extended by 1.9° in adults. Thus, the adolescent participants extended their LS relative to the hip joint during trunk extension more than adults, consistent with research that adolescent soccer players have tight quadriceps femoris muscles.[10] It was presumed that this tightness of the lower limb muscles restricted hip ROM during trunk extension, and that they extended their LS to compensate for the restricted hip motion.

Medical implications

It was shown that LBP inhibits lumbar extension. An elevated BMI in participants may increase the load stress on the LS, but there was only one participant in the current study, in the LBP group, whose BMI was over 24.0, which should not have affected the results. Therefore, a larger LPR could associate with LBP, coaches and athletic trainers should pay attention to high LPR during trunk extension.

Limitations

The limitation of this study was that the current study could not offer suggestions regarding the causative factors for LBP because of the cross-sectional design. Prospective studies are needed that assess other joints and muscle functions if it is going to be explained the relationship between LBP and the LPR during trunk extension.

It was presumed that the lower limb muscle tightness among adolescents may have restricted hip ROM during trunk extension, because compared to adults the adolescent soccer players may have had greater tightness of the quadriceps femoris muscle.[10] In a future study, assessment of muscle tightness around the hip joint would be needed, such as the quadriceps and iliopsoas muscles, which affect hip motion. And, it would be needed to clarify how disk degeneration and spondylolysis affect the LPR during trunk flexion or extension.

CONCLUSIONS

The results of the current study indicate that LBP inhibited lumbar motion relative to hip extension. There was no significant difference between the groups in terms of the LHR. However, the LPR was smaller in the LBP group than in the non-LBP group. A longitudinal observational study among adolescent soccer players with and without LBP is needed to clarify causative factors contributing to LBP based on the LPR.

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